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Advances and challenges of reducing adult educational inequalities in stomach cancer: a time series study, Colombia, 1998-2015

Avanços e desafios na redução das desigualdades educacionais no câncer de estômago em adultos: um estudo de série temporal, Colômbia, 1998-2015

Avances y desafíos en la reducción de las desigualdades educativas en cáncer de estómago en adultos: un estudio de serie temporal, Colombia, 1998-2015

Laura Isabel Vásquez (https://orcid.org/0000-0002-6909-7387) [1]
Martha Saiz (https://orcid.org/0000-0002-6906-3953) [1]
Ivan Arroyave (https://orcid.org/0000-0001-9989-5833) [2]

Abstract *Trends in educational inequalities in adult (25 years old and over) gastric cancer mortality by sex and age group in Colombia from 1998-2015 were analyzed. An ecological time series study was conducted using Colombian vital statistics and official population estimations. Age-standardized mortality rates (ASMR per 100,000 person-years) for gastric cancer were calculated separately by educational level, sex, and grouped age. A Poisson regression model was used to calculate rates ratios (RR) and the Relative Index of Inequalities (RII). The changes over time of the ASMR and RII were analyzed using a joinpoint analysis. During the study period, 80,520 deaths from gastric cancer were recorded among adults, 60% among men. Higher ASMRs were found in the lower educational levels. The inequality measured by the RII was lower among women compared to men. Young and middle-aged men suffered from the highest relative inequalities, while older men bore the toll of higher mortality rates and a greater increase in relative inequalities. It is necessary to address public health programs aimed at strengthening the quality of life of the populations identified as at risk of stomach cancer.*
Key words *Stomach cancer, Socioeconomic status, Health inequalities, Educational level, Descriptive epidemiology*

Resumo *O objetivo é analisar as tendências das iniquidades educacionais na mortalidade por câncer gástrico em adultos (25 anos ou mais), por sexo e faixa etária na Colômbia, de 1998 a 2015. Estudo ecológico de séries temporais usando estatísticas vitais colombianas e estimativas populacionais oficiais. Foram calculadas taxas de mortalidade padronizadas por idade (TMPI por 100.000 pessoas-ano) para câncer gástrico por nível educacional, sexo e faixa etária. Os rate ratios (RR) e o índice de desigualdades relativas (RDI) foram calculados por meio de regressão de Poisson. As mudanças ao longo do tempo no TMPI e RDI foram analisadas usando análise de joinpoint. Foram registrados 80.520 óbitos por câncer gástrico entre adultos, 60% entre homens. Maiores TMPI foram encontrados em níveis educacionais mais baixos. A desigualdade medida pelo IDR foi menor nas mulheres do que nos homens. Foram encontradas maiores desigualdades relativas em homens jovens e de meia-idade, e taxas de mortalidade mais altas e um maior aumento nas desigualdades relativas em homens mais velhos. É necessário abordar programas de saúde pública voltados para o fortalecimento da qualidade de vida das populações identificadas como estando em risco de câncer de estômago.*
Palavras-chave *Câncer de estômago, Nível socioeconômico, Inequidades em saúde, Nível educacional, Epidemiologia descritiva*

Resumen *El objetivo es analizar las tendencias de las inequidades educativas en la mortalidad por cáncer gástrico en adultos (25 años y más), por sexo y grupo de edad en Colombia, 1998-2015. Estudio de series de tiempo ecológicas utilizando estadísticas vitales colombianas y estimaciones oficiales de población. Las tasas de mortalidad estandarizadas por edad (TMEE por 100.000 personas-año) por cáncer gástrico se calcularon por nivel educativo, sexo y grupo de edad. los rate ratios (RR) y el Índice Relativo de Inequidades (IRI) se calcularon mediante regresión de Poisson. Los cambios a lo largo del tiempo en TMEE y IRI se analizaron mediante análisis de puntos de unión. Se registraron 80.520 muertes por cáncer gástrico entre adultos, 60% entre hombres. Se encontraron TMEE más altas en niveles educativos más bajos. La desigualdad medida por el IDR fue menor para las mujeres que para los hombres. Se encontraron mayores desigualdades relativas en los hombres jóvenes y de mediana edad, y los hombres de mayor edad sufrieron mayores tasas de mortalidad y un mayor aumento de las desigualdades relativas. Es necesario abordar programas de salud pública dirigidos a fortalecer la calidad de vida de las poblaciones identificadas en riesgo de padecer cáncer de estómago.*
Palabras clave *Cáncer de estómago, Nivel socioeconómico, Desigualdades en salud, Nivel educativo, Epidemiología descriptiva*

[1] Universidad Pedagógica y Tecnológica de Colombia. Tunja Boyacá Colombia.
[2] National School of Public Health, University of Antioquia. Calle 62 #52-59. 050010474 Medellin Colombia. ivan.arroyave@udea.edu.co

Introduction

Cancer is the second cause of death after cardiovascular diseases in the world[1], thus representing 14% of total world mortality. Risk factors classically associated with gastric cancer are dietary factors, improper food preservation, and Helicobacter pylori infection[2]. In turn, gastric cancer mortality has ranked fourth among all cancer classes since 2015[3], being the leading cause of cancer death in men[4]. More than half (4.4 million) of the eight million cancer deaths occurred in people under 70 years old[5]. Of these, 44% occurred in upper-middle-income countries (UMICs), such as Colombia, while only eight percent occurred in low-income countries (LICs)[6,7]. Inequalities in cancer survival rates between and within countries differ for reasons such as variations in education, access to specialized care, timely treatment, and the status of health insurance[8,9].

In Colombia, mortality from malignant neoplasms was the third leading cause of death in men and the second in women between 2003 and 2012. It represented 16.6% (157,017 deaths) of all deaths, with gastric cancer being the leading cause of death. Death among all cancer groups represented 14.1% of deaths in both sexes and a standardized mortality rate of 14.2/100.000 inhabitants[10].

Despite the efforts directed by the World Health Organization (WHO) to address the social causes of poor health and avoidable health inequalities[11], persistent inequalities in the distribution of wealth and access continue to be an obstacle to the improvement of the health conditions of the communities[12].

Social inequalities manifest themselves in different categories, such as social class, educational level, gender, age, ethnicity, disability, and geographic location[13,14]. Educational inequalities may contribute to socioeconomic inequality, and it is a matter of main interest worldwide due to the strong association that exists between education and health[8]. This relationship is driven by differences in lifestyle, health behaviors, and accessibility to timely cancer care[15] from an individual and social perspective[16].

Health inequalities have been documented mainly in Western countries[17], leading to an increasing desire at the international level to formulate policies under the Social Determinants of Health (SDH) approach as the main action to reducing inequalities[11]. In a previous study in Colombia, we found that the main contributor to educational inequalities in cancer mortality among men was gastric cancer (49%). It was the second-highest contributor among women after cervical cancer[18]. As Colombia is a country with great socioeconomic inequalities, there are marked differences in life expectancy and mortality from different causes[19], and as it has formally adopted a health model under the framework of the SDH, there is a growing need for an analysis of health inequalities[20]. In response to the above, the SDH model proposed by the WHO highlights the importance of thoroughly analyzing socioeconomic inequalities[21] to reorient effective actions and interventions at a global level in public health aimed at reducing cancer mortality[22]. We assume the analysis of educational inequalities to provide useful input for public programs and policies[12].

In this article, an analysis of trends in educational inequalities in gastric cancer mortality by sex and age group in Colombia from 1998 to 2015 was conducted.

Materials and methods

Research design

An ecological time series study was conducted using Colombian vital statistics and official population estimations.

Geographical context

Colombia is an Upper Middle-Income Country (UMIC) located in South America (23). The population of the country increased during the studied period (1998-2015) from 38,088,000 to 46,314,000 (24).

Colombian geography is highly variable, including two coastal regions, the north extremity of the Andes range, and plains and forests with enormous biodiversity and natural resources[25], but also with regions with very limited geographical access where the state has very little control, and, consequently, large areas of the country are dominated by various armed criminal groups funded by drug trafficking and other illegal activities[26].

The quality and accessibility of education in Colombia are also low, with private education being significantly superior to state education[27]. In the studied period, the share of the population with primary or lower educational levels steadily decreased, while participation in both secondary and tertiary education increased, with a much higher increase in those with secondary education[28].

Finally, most of the total mortality in Colombia during the recent decades is driven by chronic diseases, mainly cardiovascular diseases, and secondly by Injuries due to external causes, predominantly homicide, suicide and traffic accident[1].

Variables of interest

For the analysis, data from four variables were considered: year, sex, five-year age, and educational level, which was the socioeconomic status (SES) explanatory variable of this study.

Age was grouped into three categories: young adults (25-44 years), middle-aged adults (45-64 years of age), and older adults (65 years of age and over).

Educational levels were classified into three categories (according to the last grade level coursed): primary (up to primary), secondary (high school), and tertiary (higher education: technical, technological, and university).

Study population (deaths)

Deaths by *malignant stomach tumors* (C16 according to tenth revision of the International Classification of Diseases – ICD 10), were introduced in the study. The main inclusion criterion was that the age of death had been at least 25 years of age since it has been observed that Colombians, in general, have completed their full educational cycle by that age[29].

The data used were taken from national mortality records between 1998 and 2015, obtained from official mortality records and population projections from the National Administrative Department of Statistics (referred to by its Spanish acronym DANE).

Population data

The yearly population data were obtained from the DANE population projections by year, sex, and 5-year age, based on censuses and surveys. Yearly educational levels by these variables were calculated in three stages:

1. The proportion of individuals according to educational level (distributed according to the five-year age group, sex, and year) was obtained from the National Demographic and Health Survey (DHS) corresponding to the years 1995, 2000, 2005, and 2010 [REF].

2. The annual population size for each DHS educational level was obtained by multiplying the percentage of individuals in each educational category by the population count of the annual projections of the DANE census.

3. Smoothed interpolations were performed on the remaining years to obtain annual population counts using the PASEX demographic software.

Analyses

The information about the sex and age variables was found to be available in almost 100% of cases, while for educational level, 17% (men) and 16% (women) were missing counts of death by stomach cancer. The aforementioned limitation could lead to a possible overestimation of the educational inequalities due to the potentially higher rates of missing education for lower-educated individuals. However, we imputed missing values for educational level using a multiple imputation process through the IVEWARE[30] package, based on a broad set of demographic variables: age, sex, marital status, region, and urban/rural residence, thereby limiting the potential impact of this source of bias.

The Age Standardized Mortality Rates expressed per 100,000 person-years (ASMR) were estimated by sex, educational level, and year, using the direct method and the WHO 1997 standard[31].

The relative inequalities in mortality were evaluated by calculating the Relative Risk (RR) by educational group, with the highest educational level as a reference, and the Relative Inequality Index (RII) with independent Poisson regression models. The number of deaths was used as the dependent variable, and the natural logarithm of the person-year as the offset variable[32]. Age and educational levels were used as independent variables through a regression of mortality at the midpoint of the cumulative distribution of education, taking into account the population size of each group and comparing the risk of the educational level with the lowest versus the highest risk[33]. The figures, calculated using the Poisson regression model, are presented with confidence intervals ($\alpha = 0.05$). To evaluate changes over time in the ASMR, the annual percentage change (APC) was calculated based on a Poisson model that incorporated an interaction between educational level and year[34]. The verification of the statistical significance of the changes was performed using the joinpoint regression analysis, using the Monte Carlo permutation method to identify the best reference point (inflection point), where the rate of increase or decrease changes significantly[35].

Statistical analyses were performed in SAS version 9.4. The level of significance used was $p < 0.05$.

Ethical statement

In accordance with resolution 8430 of 1993 issued by the Colombian Ministry of Health, this study is considered of "No risk."

Results

During the study period, 80,520 deaths from gastric cancer were recorded in people over 25 years of age, of which 60% (n = 46,570) corresponded to men and the remaining 40% (n = 31,851) to women (Table 1).

According to age-standardized mortality rates (ASMR per 100,000 person-years), Table 1 shows that men were the most affected group, with 26.4/100,000 versus 15.5/100,000

Table 1. Counts (deaths, population), Age Standardized Mortality Rates (ASMR), Rate Ratios (RR) and Relative Index of Inequality (RII) of stomach cancer among adult Colombian women (25+ years), calculated for the whole period (1998-2015) separately by age groups and educational level.

	Age group	Educational level	Deaths	Population-year (thousands)	ASMR and SE by age groups and educational level		ASMR and SE solely by age groups		Rate Ratios (RR) with 95% CI	Relative Index of Inequality (RII) with 95%CI	Relative Index of Inequality * year (RII*year) with 95%CI
					Rate	SE	Rate	SE			
	All adults (25 years and more)	**Primary**	**38.683**	**94.078**	**30.32**	**0.16**			**2.32 (2.29-2.35)**	**2.89 (2.85-2.93)**	**1.01 (1.01-1.01)**
		Secondary	**7.386**	**68.273**	**21.09**	**0.28**	**26.36**	**0.12**	**1.60 (1.59-1.62)**		
		Tertiary	**2.601**	**36.624**	**12.39**	**0.28**			**1.00**		
Men	Young adult (25-44 years)	Primary	1.822	37.439	4.48	0.11			2.45 (2.42-2.49)	3.17 (3.11-3.23)	0.99 (0.99-1.00)
		Secondary	1.236	45.909	2.94	0.09	3.30	0.06	1.63 (1.60-1.65)		
		Tertiary	398	24.807	1.81	0.09			1.00		
	Middle-age adult (45-64 years)	Primary	11.557	35.534	31.32	0.29			2.32 (2.27-2.38)	3.17 (3.10-3.24)	1.02 (1.02-1.03)
		Secondary	3.278	19.159	19.42	0.30	25.42	0.20	1.46 (1.43-1.50)		
		Tertiary	1.192	9.742	12.95	0.31			1.00		
	Senior adult (65 years and more)	Primary	25.304	21.105	119.89	0.47			2.35 (2.30-2.38)	2.63 (2.57-2.66)	1.02 (1.02-1.02)
		Secondary	2.873	3.205	89.64	0.94	110.62	0.65	1.78 (1.76-1.81)		
		Tertiary	1.011	2.075	48.72	1.71			1.00		
Women	All adults (25 years and more)	Primary	25.475	100.250	17.44	0.11			1.96 (1.95-1.96)	2.66 (2.63-2.69)	0.98 (0.98-0.98)
		Secondary	4.977	75.371	11.13	0.20	15.46	0.09	1.29 (1.29-1.30)		
		Tertiary	1.399	40.634	8.13	0.29			1.00		
	Young adult (25-44 years)	Primary	1.342	36.369	3.35	0.18			1.94 (1.91-1.99)	2.26 (2.22-2.34)	1.03 (1.02-1.03)
		Secondary	1.267	49.177	2.70	0.11	2.72	0.05	1.54 (1.53-1.56)		
		Tertiary	482	30.201	1.79	0.09			1.00		
	Middle-age adult (45-64 years)	Primary	6.220	39.506	14.97	0.29			2.01 (1.99-2.04)	2.90 (2.88-2.94)	1.02 (1.02-1.03)
		Secondary	1.842	22.173	8.88	0.30	12.27	0.13	1.24 (1.22-1.27)		
		Tertiary	588	9.428	7.26	0.31			1.00		
	Senior adult (65 years and more)	Primary	17.912	24.375	73.49	0.47			2.02 (2.01-2.05)	2.89 (2.79-2.93)	0.99 (0.98-0.99)
		Secondary	1.868	4.020	46.46	0.94	68.40	0.48	1.29 (1.26-1.31)		
		Tertiary	329	1.005	32.73	1.71			1.00		

Notes: a: Educational attainment values registered after final imputation. Primary = up to elementary or primary school; secondary = any level of high school; tertiary = any level of postsecondary education after high school including college and university. b: Stomach cancer deaths after imputation. c: ASMR: age standardized mortality rates per 100,000 population and SE: standard error; all estimates (standard population OMS-1997) for educational level combine results from five databases generated by multiple imputations, appropriately reflecting uncertainty attributable to missing values. Cases with missing information on age, those with a death certificate issued by a non-medical doctor, and causes based on symptoms were also based on relative frequencies. d: Rate Ratios (RR) and Relative Index of Inequality (RII): All estimates where calculated using Poisson regression models; educational level combines results from five databases generated by multiple imputations, appropriately reflecting uncertainty attributable to missing values.

Source: Authors.

for women. When discriminating by age group, it is observed that the group with the most representative values was older men (ASMR 110.6/100,000), with older women following far behind (ASMR 68.4/100,000). Generally, the highest ASMRs were concentrated in the oldest age groups throughout the study period.

When evaluating the information related to educational level (Table 1), higher ASMRs were evidenced in the lower educational levels (men 30.3/100,000; women 17.4/100,000). This behavior was observed in all age groups.

In general, the ASMR (Figure 1) shows a downward trend in both sexes. In the period 1998-2012, men went from 33.5/100,000 to 22.0/100,000; from here on, the ASMRs increased slightly. Regarding women (1998-2011), the ASMRs went from 19.7/100,000 to 12.0/100,000. Unlike men, the rates remained constant until the end of the period, an effect reflected in the joinpoint, capturing these two points of inflection.

In the analysis of ASMR trends by age groups (Figure 2), there is a clear decrease in the rates for both sexes, in the middle-aged adult groups, and particularly in older adults, with a significant decrease in men for 2004-2011 of 4.9% APC and in women of 7.7% APC.

Regarding the behavior of the ASMR according to the educational level (Figure 3), it is evident that the tertiary level for both sexes presented greater decreases compared to the other two levels (until 2010), being significant for both sexes. A larger gap can be observed for the entire period between the ASMRs of the group of women: for the first segment (1998-2013) APC-tertiary = + 6.3% against APC-secondary = -3.4%, and for the second segment (2000-2010) APC-primary = -4.1% against APC-tertiary = + 11% between 2013 and 2015. The joinpoint analysis showed a final period of increase for both sexes at the secondary and tertiary educational levels. All these values were significant.

Regarding the RR, it was higher among young men, showing a decrease in older adults (65 years of age and over). Unlike men, inequality in women grew with age, going from 2.26 (95%CI: 2.22-2.34) in the group of young women to 2.89 (95%CI: 2.79-2.93) in older women (Table 1).

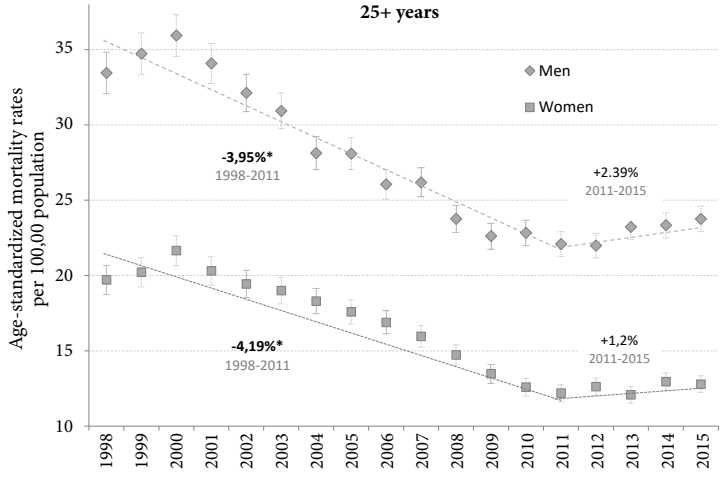

Figure 1. Trend of standardized mortality rates by age (ASMR) for stomach cancer for men and women over 25 years, including Annual Percentage Change (APC) based on joinpoint models, Colombia, 1998-2015.

Markers: age-standardized stomach cancer mortality rates were observed among adults over 25 years. The points represent ASMR, the lines represent the trend lines between junction points. The numbers adjacent to the lines represent estimates of the annual percentage change (APC) during the corresponding periods, depending on the joinpoint model; a star indicates statistical significance at $\alpha = 0.05$.

Source: Authors.

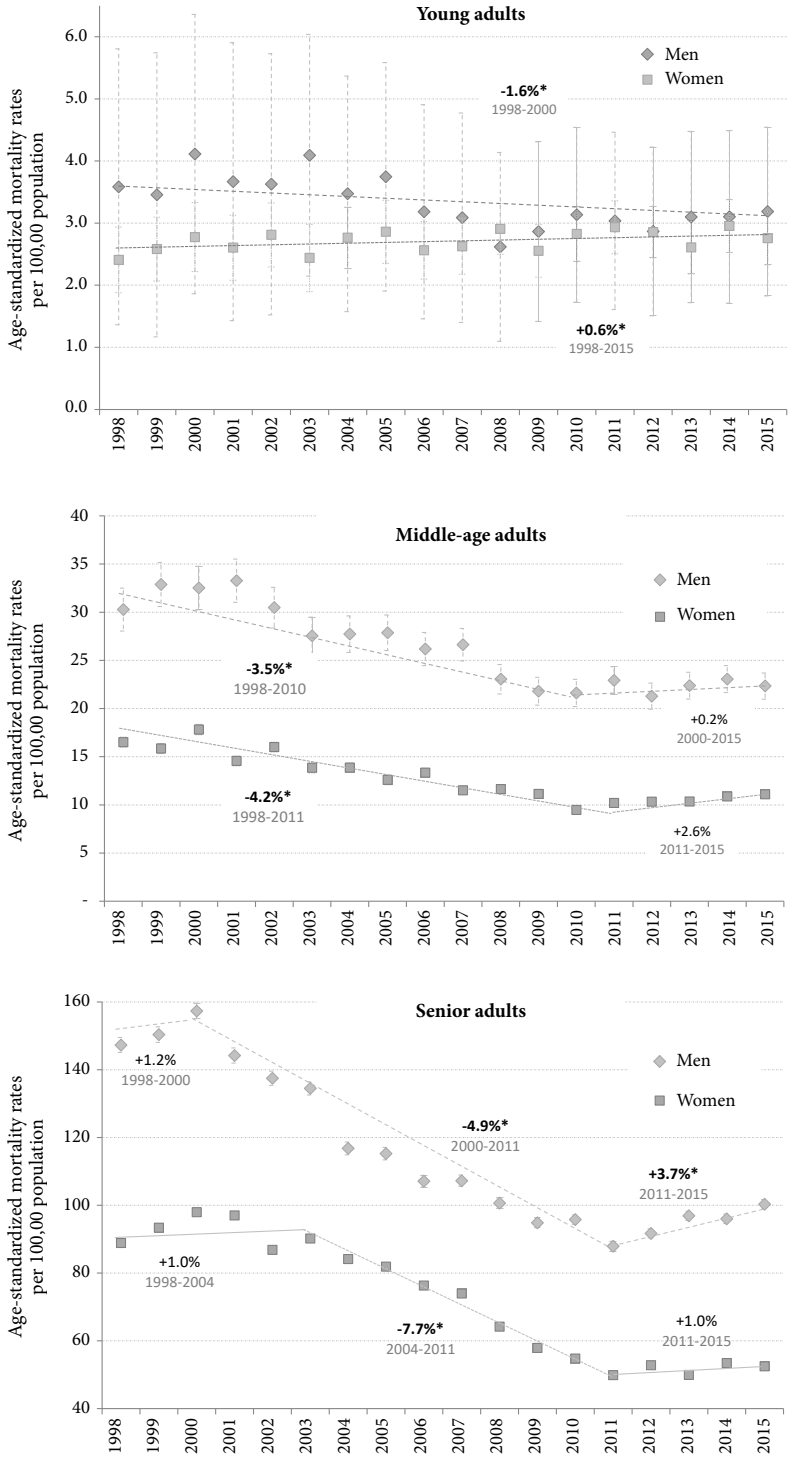

Figure 2. Trend of standardized mortality rates by age (ASMR) for stomach cancer for men and women over 25 years, including Annual Percentage Change (APC) based on **j**oinpoint models, educational level, Colombia, 1998-2015.

Trends in age-standardized mortality rates (ASMR) due to stomach cancer for cases without age or medical certificate. Markers: age-standardized stomach cancer mortality rates were observed among adults over 25 years. The points represent ASMR, the lines represent the trend lines between junction points. The numbers adjacent to the lines represent estimates of the annual percentage change (APC) during the corresponding periods, depending on the joinpoint model; a star indicates statistical significance at $\alpha = 0.05$.

Source: Authors.

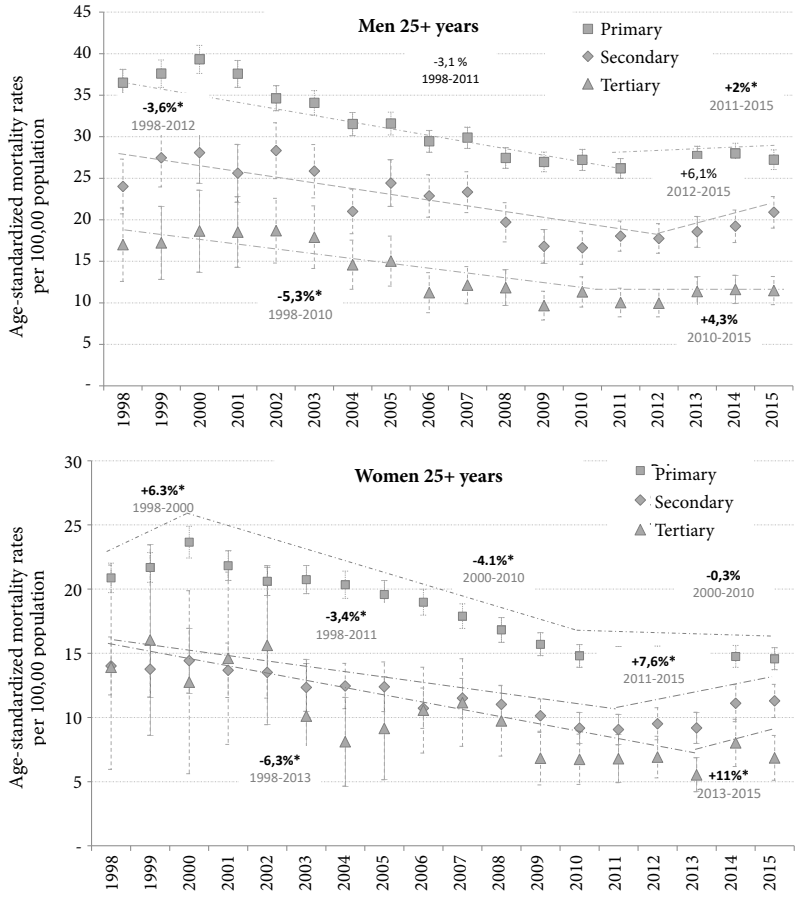

Figure 3. Trend of standardized mortality rates by age (ASMR) for stomach cancer for men and women over 25 years, including annual percentage change (APC) based on joinpoint models, educational level, Colombia, 1998-2015.

Trends in age-standardized mortality rates (ASMR) due to stomach cancer for cases without age or medical certificate. Markers: age-standardized stomach cancer mortality rates were observed among adults over 25 years. The points represent ASMR, the lines represent the trend lines between junction points. The numbers adjacent to the lines represent estimates of the APC during the corresponding periods, depending on the Joinpoint model; a star indicates statistical significance at α = 0.05.

Source: Authors.

Regarding the RII, the joinpoint analysis (Figure 4) presents a turning point for each sex: between 1998 and 2015, the increase in APC was + 1.0% for men, and between 2005 and 2013, the decrease in APC was -1.8% for women, thus showing a small but significant gap between the inequality of men versus women. All the exposed values are statistically significant.

Discussion

This study found a reduction in gastric cancer adult (25+ years of age) mortality rates in Colombia during the study period (1998-2015), with much higher mortality rates and relative inequalities among men, particularly the poor in informal employment and covered by the healthcare-subsidized insurance scheme, since 2003. The result is similar to that found in international studies. This progressive reduction could be attributed to the reduction in access to healthcare barriers, concomitant to the progressive achievement of uni-

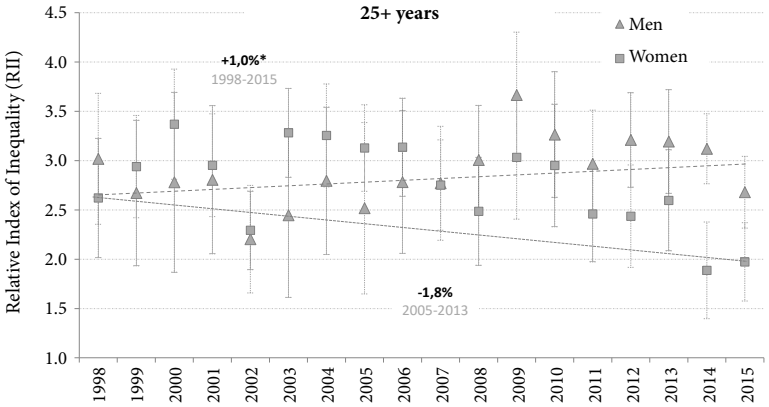

Figure 4. Trends in the Relative Inequality Index (RII) of stomach cancer mortality in men and women over 25, including annual percentage change (APC), based on joinpoint Colombia models, 1998-2015.

Trends in the Relative Inequality Index (IRD) of stomach cancer mortality for cases without age or medical certificate. Markers: age-standardized stomach cancer mortality rates were observed among men and women over 25 years. The points represent IRD, the lines represent the trend lines between junction points. The numbers adjacent to the lines represent estimates of the APC during the corresponding periods, depending on the joinpoint model; a star indicates statistical significance at $\alpha = 0.05$.

Source: Authors.

versal health insurance coverage since 2010. On the other hand, the relative educational inequalities in gastric cancer mortality did not reduce during the period, which can be partially appointed to persistent limited access to endoscopic early diagnosis and timely treatment. Older lower-educated men bore the very highest toll of mortality, similar to the findings of other studies, and in the higher increase in relative inequalities.

Comparison with previous studies

Gastric cancer ASMR trends in Colombia (1998-2015) found in this study are in line with worldwide evidence since most countries have presented mortality decreases in stomach cancer during recent decades[36,37,38]. For instance, a study in different European settings (Denmark, Finland, metropolitan France, the Netherlands, Norway, Sweden, England, and Wales), found a significant average annual gastric cancer mortality decrease of 4.2% between 1980 and 2005[39] greater than in this study: -2.4% among men and -3.2% among women. This difference reveals that Colombia has to improve actions to further reduce gastric cancer mortality among adults.

When we compare the studied sex/age groups (young, middle-aged, and senior men and women), less-educated men, particularly the elderly, have the highest mortality rates and the lowest reduction in both adjusted mortality rates and relative inequalities. This coincides with a study conducted on gastric cancer morbidity in Korea that found that among elderly men (60-69 years old), the lowest income group had a higher mortality ratio if compared with the highest income group[40].

Explanations of the results

Health insurance coverage greatly increased in Colombia, particularly since 2003, due to a reform in the decentralization regulations, achieving universal coverage in health insurance since 2010[18], using more than 95% of the population with health insurance coverage as a reference, accompanied by important improvements in funding and institutional strengthening[41]. This probably contributed to the continuous reduction in adult gastric cancer mortality rates in the study period. In general, adult gastric cancer mortality rates reached a peak in 2000 and, from then on, a decrease parallel to the increase in insurance coverage since 2003 and, later, to the growth in healthcare services coverage since 2008 for those subsidized. This is particularly true for those identified as more vulnerable, affiliated to a subsidized insurance scheme[42,43]. In contrast, limitations in access to preventive healthcare services

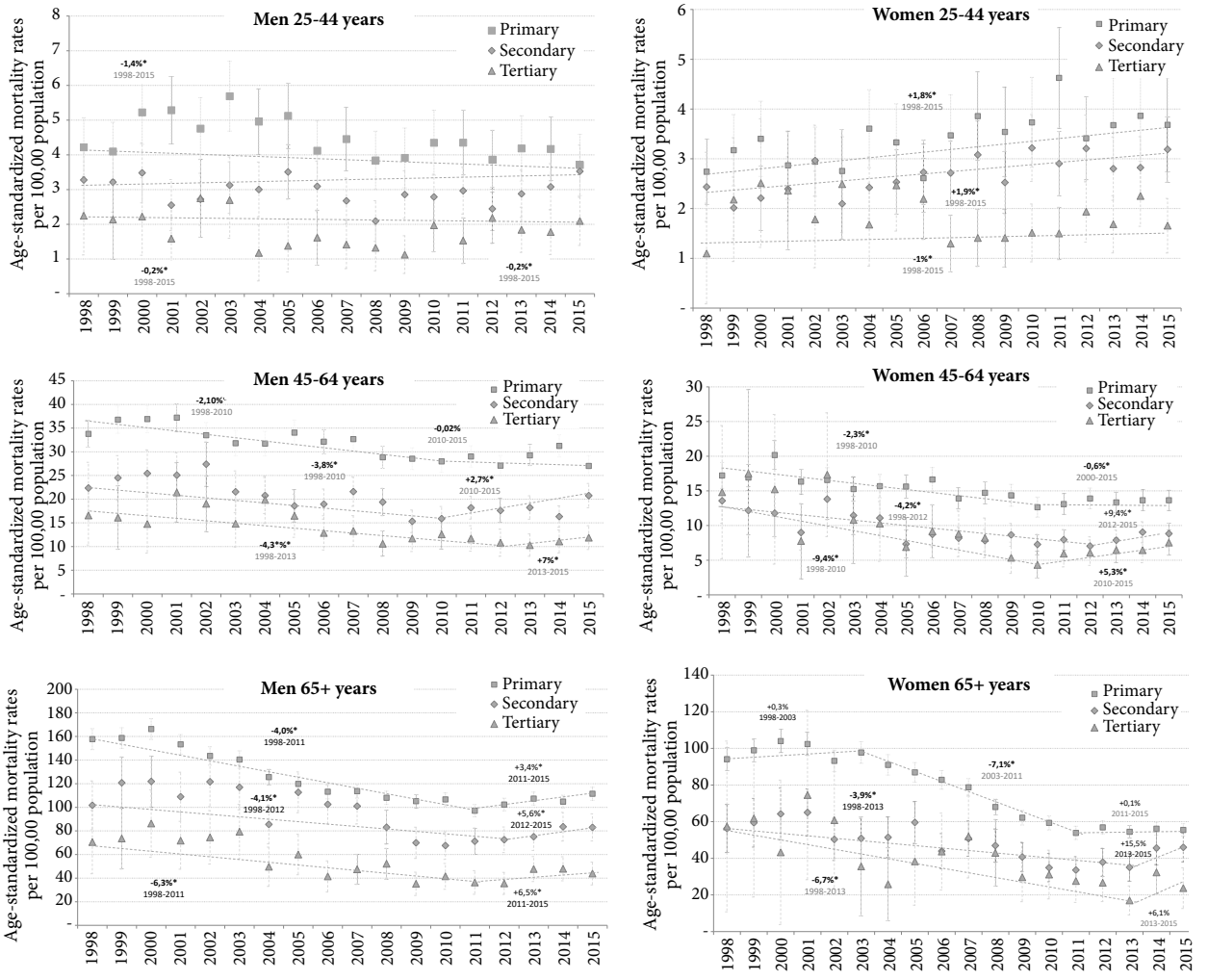

Figure 5. Trend of standardized mortality rates by age (ASMR) stomach cancer for men and women over 25 years by education level for each age group, Colombia, 1998-2015.

Markers: age-standardized stomach cancer mortality rates were observed among adults over 25 years. The points represent ASMR, the lines represent the trend lines between junction points. The numbers adjacent to the lines represent estimates of the annual percentage change (APC) during the corresponding periods, depending on the joinpoint model; a star indicates statistical significance at α = 0.05.

Source: Authors.

for cancer prevention remain, in particular regarding early diagnosis and timely treatment for poor and rural populations[44].

Therefore, despite the decreasing trend of ASMRs in stomach cancer mortality, the relative educational inequalities did not reduce significantly during the study period. This is due to the ASMRs in the lowest educational groups decreasing slowly, while those with higher educational levels decreased more quickly or remained stable with insignificant increases. A previous study found similar trends in the Colombian population from 1998-2003, with a significant decrease in gastric cancer mortality rates, observing particularly strong and statistically significant decreases among men with primary educational levels[45].

It is important to underline that endoscopic early diagnosis for gastric cancer has been included in the National Health Benefit Plan for those in the subsidized regime a decade later (2008) and those in the contributory scheme, i.e., those with formal employment[46]. In fact, the survival rates for stomach cancer had been

analyzed in previous research, and it was found that approximately 65% of the population that survived were in the contributory regime[47]. In the same vein, and in line with our finding of a higher burden of gastric cancer mortality and educational inequalities among less-educated senior men, a study conducted in several Central Latin-American countries geographically close to Colombia concluded that patients who received timely treatment were more likely to survive, unlike patients with low incomes, particularly those over 55, with a lower probability of receiving treatment[48]. Comparable results were obtained in Korea (1998-2012), identifying persistent healthcare access barriers characterized by a manifest inequality in access to gastric cancer detection among lower-income quintiles versus the highest quintiles[49]. Also, in line with our study, higher mortality rates particularly among senior men in China were found[50].

According to the results obtained, it can also be hypothesized that the decrease observed during the entire period of the ASMRs among men and women with lower educational levels, particularly among young and adult age groups, could be explained by timely access to universal healthcare insurance coverage, as well as the commitment of reducing access barriers linked to the shared payments of the subsidized regime[51], and by the strengthening of surveillance, detection, timely treatment, and other actions contemplated in the public health plan comprehensive approach to cancer control[52].

Limitations of the study

There are two major limitations in this study: Firstly, the ecological bias inherent in the design of the study, for which the estimated associations cannot be interpreted as causal effects. However, the ample size of the dataset contributes to reducing the chance of ecological error[53].

Secondly, although Colombia has an appropriate Vital Statistics registration, the results of the study depend on the completeness and quality of the cause of death records in the use of secondary data.

Regarding the completeness of the dataset, non-coverage in Colombia reached 9.9% in 2002, as referenced in a study[54]. A previous study, which used life tables as a reference to calculate under-registration in the Colombian deaths dataset, found that this is greater among less prosperous subnational entities (32 in total, the so-called "departments"), and that under-registration noticeably decreased during the studied period (2000-2010)[55]. Another study confirmed that under-registration is highest in the poorest regions[56]. These findings suggest that estimates of disparities in mortality by educational level are likely to have been underestimated. This may also have led to an underestimation of the extent to which inequalities have increased because under-registration decreased over the study period[55].

Regarding the size of the garbage codes (R00-R99) in the Colombian mortality dataset, a comparative study showed that garbage codes in Colombia in 2015 (22.9%) were even lower than those of the average of highly-developed countries (23.8%), and much lower than those in middle-developed countries (39.7%)[57]. According to our calculations (Figure 6), the percentage of malignant neoplasms garbage codes (C76-C80) for the study period was 14.4%, and the percentage of the garbage codes in the overall dataset (R00-R99) was 34.9%. These percentages for both malignant neoplasms and the total of deaths were greatly reduced during the study period (results not shown). As the percentage of garbage codes tend to be higher in less developed settings[48], the garbage codes in the Colombian dataset also suggest that our results underestimate the educational inequalities and their increase.

Finally, the data corresponding to mortality come from a different source than the population distribution by educational group and could have given rise to a numerator-denominator bias.

Conclusions

While stomach cancer mortality rates reduced during the study period, slow reductions in mortality among the less-educated groups contributed to upholding the social inequality gaps. These results serve as input for Colombian health authorities in the work of planning, reorientation prevention (at all levels), and health education aimed at strengthening the quality of life of the populations diagnosed (or identified with risk) of stomach cancer of all socioeconomic levels. The differences found in the ASMR and RR for stomach cancer according to age group, sex, and educational level suggest the need to propose specific interventions, considering specific population characteristics.

On the other hand, the gap identified between the RII of men versus women leads us

to analyze the orientation of public health programs (classically oriented to the promotion of protective behaviors in the female population), suggesting an orientation of the promotion of health from a gender perspective. This is advantageous since specific interventions can have differential effects on educational inequalities for men and women.

Collaborations

LI Vasquez and I Arroyave conceived the paper; I Arroyave developed the analysis strategy and carried out the analyses; LI Vasquez , I Arroyave and M Sainz collectively interpreted the findings and wrote up the work. All authors have read and approved the final manuscript.

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